

# **MOTOR ASSEMBLY HAVING IMPROVED ELECTROMAGNETIC NOISE FILTERING AND DISSIPATION**

## **BACKGROUND OF THE INVENTION**

### 5 1) Field of the Invention

[0001] The subject invention relates to a motor assembly, and more specifically to a motor assembly having improved electromagnetic noise filtering and dissipation for use in a vehicle.

### 10 2) Description of Related Art

[0002] Electric motors are a tremendous source of electromagnetic emissions, noise, or interference (EMI). It is to be appreciated that EMI may refer to either radiated or conducted emissions, noise, or interference, as understood by those skilled in the art. Most automobiles contain a number of electric motors to control the various engine  
15 functions, such as pumping hydraulic fluid for braking and steering systems, and for performing other vehicle functions such as operating windshield wipers, electric windows, electric adjustable mirrors, retractable antennas and a whole host of other functions. In addition, electric motors are used extensively in a number of home appliances such as washing machines, dryers, dishwashers, blenders, hair dryers. Due  
20 to the prevalence of electric motors and increased electromagnetic emissions standards there is a need for an assembly having differential and common mode filtering.

[0003] EMI can be radiated and conducted through electrical lines from such sources as the motor, the control units, and the like. Other sources of interference are  
25 generated from equipment coupled to the electrical lines, such as control circuits,

computers, switching power supplies, and a variety of other systems, which may generate significant interference which is desired to be eliminated to meet international emission and/or susceptibility standard requirements. Examples of such standards include automotive component EMC specification GMW-3097/3100.

5 [0004] Several other sources of EMI include cross talk and ground bounce. Cross talk in most connectors or carriers is usually the result of mutual inductance between two adjacent lines rather than from parasitic capacitance and occurs when signal currents follow the path of least inductance, especially at high frequencies, and return or couple onto nearby conductors such as conductive tracks positioned parallel with or  
10 underneath the signal current track. Ground bounce is caused by shifts in the internal ground reference voltage due to output switching of a component. Ground bounce causes false signals in logic inputs when a device output switches from one state to another.

[0005] Differential and common mode currents are typically generated in cables and  
15 on circuit board tracks. Controlling these conducted/radiated emissions is necessary to prevent interference with other circuitry or other parts of the circuit generating or sensitive to the unwanted noise. Based upon the known phenomenon of EMI, a variety of filter and surge suppression circuit configurations have been designed as is evident from the prior art. Most electric motor assemblies include multiple inductors  
20 and multiple capacitors within a housing of the motor, as well as exterior to the motor, to suppress EMI. However, as packaging space becomes limited, it is more difficult to package these components within the motor housing.

[0006] Therefore, X2Y Attenuators has arrived at a compact circuit, a capacitor, that be can be located outside the motor housing and is capable of filtering and

suppressing noise generated by the electric motors. Numerous patents disclose the specific structure of the circuit and various uses of the circuit. United States Patent No. 6,509,807 discloses the circuit mounted to a carrier. The carrier and the circuit, when coupled between an energy source and an active load, simultaneously receive and condition the energy propagating to the load in a differentially balanced manner. The conditioning functions provided by the circuit are facilitated, in part, by the electrical connection between the circuit with an external conductive path provided by the carrier. The carrier is connected to an electrical ground, such as an isolated ground, a chassis ground, or earth ground. The carrier is typically a printed circuit board having conductive regions, or tracks, and non-conductive regions, or tracks. The circuit extends across conductive regions and non-conductive regions to connect to a grounding region. United States Patent No. 5,909,350 discloses the circuit used in combination with a motor.

[0007] The carrier reduces mechanical and physical stresses such as shock, vibration and various thermal conditions which the circuit would otherwise be subjected to and provides a complete ground shield for the circuit. Because the carrier has a greater surface area than the circuit and a substantial portion of that surface area is covered by metalized ground surface, the carrier acts as a ground shield which absorbs and dissipates electromagnetic interference and over voltages.

[0008] However, it has been discovered that when incorporating the carrier and the circuit into the motor assembly, the location of the circuit on the carrier is critical and it impacts the performance of the circuit. Further, it has been determined that soldering motor terminals to the carrier may weaken the connection between the circuit and the carrier which impacts its ability to suppress EMI. If the circuit is

located between the terminals, physical stressing, bending, or applying torque to the carrier and the terminal while inserting the terminal through the carrier may cause a failure in the final product, either immediately or later thereby affecting the products overall reliability. Another drawback to using the above described circuit and carrier  
5 is that it becomes very tedious to manually handle and mount the circuit on the carrier while it is being assembled. This translates into lower product yields and added expense due to broken or misconnected components. Further, the mounting of the carrier and the circuit outside the motor housing as described in the related art is difficult, while still ensuring a secure connection between the grounding region and  
10 the electrical ground.

[0009] The prior art assemblies are characterized by one or more inadequacies. Therefore, it would be advantageous to provide a motor assembly having a reliable connection between the terminal and the carrier without lessening the connection between the carrier and the circuit. It would be further advantageous to provide an  
15 assembly having a reliable connection between the grounding region of the carrier and the electrical ground to ensure maximum EMI suppression.

### **BRIEF SUMMARY OF THE INVENTION**

[0010] The subject invention provides a motor assembly having improved  
20 electromagnetic noise or interference (EMI) filtering and dissipation for a vehicle. The assembly includes a motor having at least two terminals extending therefrom for connecting to a power source and a carrier having an upper surface and a lower surface with an outer periphery defining apertures for receiving the terminals of the motor. First and second conductive regions are disposed on one of the upper and the

lower surfaces and adjacent the apertures for electrically connecting to the terminals. A grounding region is disposed on one of the upper and the lower surfaces for grounding the carrier to an electrical ground. The first and the second conductive regions are insulated by a first non-conductive region. A circuit extends across the first non-conductive region electrically connecting the first and the second conductive regions to the grounding region for filtering EMI.

[0011] The subject invention also includes a biasing device urging the grounding region of the carrier into electrical connection with the electrical ground for dissipating EMI generated by the motor to the electrical ground. Another aspect of the subject invention includes receptacles supported by the carrier electrically connected to the first and the second conductive regions for receiving the terminals without requiring the terminals to be soldered to the carrier.

[0012] The subject invention overcomes the inadequacies that characterized the related art assemblies. Specifically, the biasing device maintains the grounding region in electrical connection with the electrical ground which ensures maximum cancellation of EMI and the receptacles securely connect the terminals to the carrier without lessening the connection of the circuit to the carrier.

#### **BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING**

[0013] Other advantages of the present invention will be readily appreciated, as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0014] Figure 1 is a perspective view of a motor having terminals extending therefrom and a carrier mounted thereto;

[0015] Figure 2 is a perspective view of an electrical ground having the motor terminals extending therethrough with the carrier in electrical connection with the electrical ground ;

5 [0016] Figure 3 is a perspective view of one embodiment of a carrier according to the subject invention;

[0017] Figure 4 is a cross-sectional view of the carrier of Figure 3 in engagement with the terminals and the electrical ground;

[0018] Figure 5 is a perspective view of an upper surface of the carrier of Figure 3 engaging the terminals of the motor;

10 [0019] Figure 6 is a perspective view of another embodiment of the carrier having receptacle mounted to the upper surface of the carrier;

[0020] Figure 7 is a perspective view of a lower surface of the carrier shown in Figure 6;

15 [0021] Figure 8 is a perspective view of the carrier of Figure 6 in engagement with the terminals and the electrical ground and being biased into contact by a biasing device;

[0022] Figure 9 is a perspective view of the lower surface of still another embodiment of the carrier;

20 [0023] Figure 10 is a perspective view of the upper surface of the carrier illustrated in Figure 9;

[0024] Figure 11 is a perspective view of the lower surface of the carrier of Figure 9 biased by the biasing device into engagement with the electrical ground;

[0025] Figure 12 is a perspective view the upper surface of the carrier of Figure 9 in engagement with the electrical ground;

[0026] Figure 13 is a perspective view of a lower surface of yet still another embodiment of the carrier having the receptacles mounted through apertures of the carrier;

[0027] Figure 14 is a perspective view of an upper surface of the carrier shown in  
5 Figure 13; and

[0028] Figure 15 is a perspective view of an alternate embodiment of the biasing device urging a grounding region into contact with the electrical ground.

### DETAILED DESCRIPTION OF THE INVENTION

10 [0029] Referring to the Figures, wherein like numerals indicate like or corresponding parts throughout the several views, a motor assembly is disclosed having improved electromagnetic noise or interference (EMI) filtering and dissipation. The motor be used in any application but is particularly suited for use in a vehicle (**not shown**). The assembly is shown generally at 20 in Figure 1. It is to be appreciated that MEI  
15 may be radiated or conducted as known by those skilled in the art.

[0030] The assembly 20 includes a motor 22 having at least two terminals 24 extending therefrom for connecting to a power source (**not shown**). The motor 22 may be any motor in the vehicle, such as, but not limited to, a motor for operating any one of windshield wipers, electric windows or sunroofs, electric adjustable mirrors,  
20 retractable antennas, fluid pumps, and the like. The motor 22 may be a two phase motor having a positive terminal and a negative terminal, a three phase motor, or any other phase motor. One embodiment of the motor 22, shown in Figure 2, is used in combination with a hydraulic control unit 26 (HCU) for pumping hydraulic fluid. The HCU 26 has a housing 28 that acts as an electrical ground 30 connected to the vehicle.

The electrical ground 30 may be any other component formed of conductive materials, such as a metal, and is grounded to the vehicle. The housing 28 of the HCU 26 is a conductive material, which is typically formed of aluminum. The housing 28 has an opening 32 through which the terminals 24 of the motor 22 extend  
5 through.

[0031] Referring to Figure 1 and 2, the motor 22 may also include a plastic tower 34 extending through the HCU 26 for protecting and insulating the terminals 24. The terminals 24 of the motor 22 extend to an electronic control unit 36 (ECU) (shown in Figure 15), which controls the vehicles function and upon sending a signal to operate  
10 the motor 22, the hydraulic fluid is pumped. It is to be appreciated that those skilled in the art may adapt the subject invention for use with any of the other motors described above.

[0032] Referring to Figures 3-9, a carrier 38 is shown having an upper surface 40 and a lower surface 42. The carrier 38 has an outer periphery 44 defining apertures 46, 48  
15 that receive the terminals 24 of the motor 22. The carrier 38 is preferably a printed circuit board, as understood by those skilled in the art, formed of a non-conductive material having a conductive material thereon. The carrier 38 is sized depending upon the particular application, such as being circular to fit the HCU 26 and ECU 36. However, when the subject invention is utilized with a motor for windshield wipers,  
20 the carrier 38 may be rectangular. The non-conductive material acts as an insulator and one example of the non-conductive material is, but not limited to, plastic. The conductive material is most preferably a metallic surface disposed on each of the upper and lower surfaces 40, 42. The conductive material is capable of being etched away by processes known to those skilled in the art to establish conductive regions



and non-conductive regions. However, it is to be appreciated that the conductive material may only be present on a single surface 40, 42 of the carrier 38 depending upon the packaging needs or the application.

[0033] The carrier 38 has a first conductive region 50 and a second conductive region 52 disposed on one of the upper and the lower surfaces 40, 42. The first conductive region 50 is adjacent one of the apertures 46, 48 for electrically connecting to one of the terminals 24 and the second conductive region 52 is adjacent the other of the apertures 46, 48 for electrically connecting to the other of the terminals 24. The first and the second conductive regions 50, 52 may completely surround the apertures 46, 48 or only about a portion of the apertures 46, 48. The first and the second conductive regions 50, 52 facilitate efficient and secure connections with the terminals 24, as will be described more fully below.

[0034] The carrier 38 also includes a grounding region 54 on one of the upper and the lower surfaces 40, 42. The grounding region 54 may extend to both of the upper and the lower surfaces 40, 42 depending upon the application of the carrier 38. Preferably, the grounding region 54 extends at least partially around the outer periphery 44 of the carrier 38, and most preferably, the grounding region 54 extends around the outer periphery 44 and splits between the terminals 24. A first non-conductive region 56 insulates the first and the second conductive regions 50, 52 from the grounding region 54. Each of the first and the second conductive regions 50, 52 and the grounding region 54 is formed from the conductive material of the carrier 38. The first non-conductive region 56 is where the conductive material has been removed from the carrier 38, as would be understood by those skilled in the art, or

vice versa depending upon the type of printed circuit board utilized in the subject invention.

[0035] A circuit 58 extends across the first non-conductive region 56 electrically connecting the first and the second conductive regions 50, 52 to the grounding region 54. The circuit 58 filters the EMI that is being transmitted from the motor 22 through the terminals 24. The circuit 58 may be a capacitor, a varistor, a resistor, or combination thereof. One most preferred circuit 58 is described in the United States Patents described above and assigned to X2Y Attenuators, L.L.C. The circuit 58 has conductive and non-conductive bands 60, 62 that align with the respective regions of the carrier 38 for completing the electrical connection. The carrier 38 is positioned adjacent to the electrical ground 30 and is electrically connected thereto. The opening 32 of the housing 28 is recessed for receiving the carrier 38 and for establishing the electrical connection.

[0036] In connecting the first and the second conductive regions 50, 52 with the grounding region 54, the circuit 58 must be positioned carefully and precisely on the carrier 38 to ensure maximum and continued performance. Therefore, a mounting region 64 is defined between the outer periphery 44 and the apertures 46, 48 of the carrier 38 for locating the circuit 58 in the mounting region 64 spaced from the apertures 46, 48. The circuit 58 may be surface mounted to the carrier 38 or may extend through the carrier 38, as understood by those skilled in the art. It has been found that when the two terminals 24 are positioned parallel to one another and the circuit 58 is positioned between the terminals 24, the force exerted on the carrier 38 and the circuit 58 when the terminals 24 are passed through the apertures 46, 48 causes the circuit 58 to fail. This may be attributed to the circuit 58 being fragile and

the force cracking the circuit 58 or the circuit 58 may become dislodged from the carrier 38. Accordingly, the circuit 58 is set-off from the apertures 46, 48 and positioned between the outer periphery 44 and the apertures 46, 48 such that the respective conductive and non-conductive regions and bands align. In order to have  
5 adequate space for the circuit 58 to be mounted, the apertures 46, 48 may be offset from a center line 66 of the circuit 58. Offsetting the apertures 46, 48 provides additional space for securing the circuit 58 to the carrier 38.

[0037] One embodiment of the carrier 38 is shown in Figure 3 having the first and the second conductive regions 50, 52, the non-conductive region, and the grounding  
10 region 54 all on the same surface of the carrier 38. The circuit 58 is mounted in the mounting region 64 spaced from the apertures 46, 48. In Figure 4, the apertures 46, 48 of the carrier 38 receive the terminals 24 of the motor 22 and the grounding region 54 is in contact with the electrical ground 30.

[0038] Another embodiment of the carrier 38 is shown in Figures 6 and 7 having the  
15 first and the second conductive regions 50, 52 and the non-conductive region on both the upper and the lower surfaces 40, 42, and the circuit 58 and the grounding region 54 on the upper surface 40. Any EMI from the terminals 24 is dissipated into the first and second conductive regions 50, 52 on the lower surface 42 and is passed to the upper surface 40. The EMI is then transmitted through the circuit 58 on the upper  
20 surface 40 into the grounding region 54. Figure 8 illustrates the carrier 38 mounted to the electrical ground 30 for dissipating the EMI. However, the electrical ground 30 has a raised lip 88 to engage the grounding region 54 more towards the center of the carrier 38. This helps to ensure a solid electrical connection therebetween.

[0039] Still another embodiment of the carrier 38 is illustrated in Figures 9 and 10. The carrier 38 has the first and the second conductive regions 50, 52, the non-conducting region, and the circuit 58 on the lower surface 42. The grounding region 54 is located on the both upper and the lower surfaces 40, 42. The EMI is transmitted from the terminals 24 to the first and the second conductive regions 50, 52 on the lower surface 42. The EMI flows through the circuit 58 and into the grounding region 54 on the lower surface 42, which passes it to the grounding region 54 on the upper surface 40. Figures 11 and 12 illustrate the grounding region 54 on the upper surface 40 in contact with the electrical ground 30 for grounding the EMI.

[0040] In each of the embodiments illustrated in Figures 3-14, the terminals 24 are connected to the carrier 38 and the first and the second conductive regions 50, 52 without soldering. It is advantageous to connect the terminals 24 without soldering because soldering may loosen the circuit 58 from the carrier 38 and provide faulty connections. If the terminals 24 are not soldered, then the connection between the terminals 24 and the first and the second conductive regions 50, 52 must remain stable enough to dissipate the EMI. Specifically, referring back to Figures 3 through 5, the terminals 24 include tabs 68 extending outwardly for electrically connecting to the first and the second conductive regions 50, 52. Once the terminals 24 are inserted through the carrier 38, the tabs 68 lock into the apertures 46, 48 creating a secure connection. In such an embodiment, the apertures 46, 48 must be electrically conductive, or through plated, as understood by those skilled in the art.

[0041] In Figures 6 through 14, receptacles 70 are mounted to the carrier 38 for electrically connecting the terminals 24 to the first and the second conductive regions 50, 52. The receptacles 70 are formed of a conductive material, such as, but not

limited to, copper, tin plated brass, or spring steel. The spring steel is preferred because it provides the tension for an interference fit. The receptacles 70 are sized to receive the terminals 24 and create an interference fit therebetween. The receptacles 70 allow for a secure connection between the terminals 24 and the first and the second  
5 conductive regions 50, 52 without having to solder the terminals 24 to the carrier 38. Various methods would be recognized by those skilled in the art to create the interference fit, such as including tangs 72 within the receptacles 70 for electrically connecting the terminals 24 to the receptacles 70. The tangs 72 bias inwardly from the periphery of the receptacles 70 and against the terminals 24. When the terminals  
10 24 are inserted into the receptacles 70, the tangs 72 are pushed outwardly and the counter acting inward force of the tangs 72 frictionally secures the terminals 24 in the receptacles 70. It is preferred that the tangs 72 have a surface area coextensive with the terminals 24 to allow for maximum filtering and dissipation of EMI.

[0042] In order to mount the receptacles 70 to the carrier 38, projections 74 may  
15 extend either through the carrier 38 or in abutting engagement with the apertures 46, 48. The receptacles 70 may also be directly surface mounted to the carrier 38, with or without the projections 74, and in contact with the conductive regions 50, 52. The projections 74 establish the electrical connection between the receptacle and the first and the second conductive regions 50, 52. Since the receptacles 70 can be secured to  
20 the carrier 38 prior to circuit 58, the projections 74 may be soldered to the carrier 38. Alternatively, the receptacles 70 may be bent over to secure the receptacles 70 to the carrier 38 without soldering. In Figures 7 and 9, the projections 74 are illustrated as extending through the carrier 38 and being bent into engagement with the first and the

second conductive regions 50, 52. Whereas in Figure 13, the projections 74 extend through and into abutting engagement with the apertures 46, 48.

[0043] Referring to Figures 4, 8, and 15, a biasing device 76 urges the grounding region 54 of the carrier 38 into electrical connection with the electrical ground 30.

5 Any EMI generated by the motor 22 is filtered through the circuit 58 and dissipated to the electrical ground 30, as discussed above. However, in order to dissipate a maximum amount of EMI, the grounding region 54 must be securely connected to the electrical ground 30. In the embodiment shown in Figure 4, the biasing device 76 is illustrated as the outer periphery 44 of the carrier 38 having threads 78 and the  
10 electrical ground 30 being threaded 80 for receiving the carrier 38. The threaded 80 outer periphery 44 maintains the carrier 38 in contact with the grounding region 54. The threads 80 may act as a snap-fit and create an electrical connection therebetween.

[0044] In Figure 8, the biasing device 76 is illustrated as a grommet 82 engaging the terminals 24 and maintaining the grounding region 54 in contact with the electrical  
15 ground 30. The grommet 82 has slots slightly larger than the terminals 24 that frictionally engage the terminals 24. Once the grommet 82 is abutted against the carrier 38, the carrier 38 will not be able to become unseated from the grounding region 54 ensuring a solid connection. The grommet 82 is preferably formed of a non-conductive material, such as rubber. The grommet 82 also provides  
20 environmental protection to ensure that any fluid does not escape from within the housing 28, and acts like a secondary seal.

[0045] In Figure 15, the biasing device 76 is illustrated as a spring 86 engaging the carrier 38 and biasing the grounding region 54 in contact with the electrical ground 30. It is to be appreciated that the biasing device 76 may be other than as described as

above, such as, but not limited to fasteners **(not shown)** extending through the carrier 38 and into the housing 28 to continuously urge the grounding region 54 in contact with the electrical ground 30.

[0046] While the invention has been described with reference to an exemplary embodiment, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.